DURABILITY INVESTIGATION OF BURNER RIG OF Yb_2SiO_5 ENVIRONMENTAL BARRIER COATINGS

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Keywords: Environmental barrier coatings, Burner rig, Yb_2SiO_5, Delamination, Recession

Environmental barrier coatings (EBCs) are applied to SiC/SiC ceramic matrix composites (CMCs) to protect them from water vapor oxidation during operation. The durability of EBCs was typically evaluated using furnace steam oxidation tests[1]. However, these tests are isothermal and differ from the temperature-gradient conditions of the actual operating environment. Moreover, steam velocity is often significantly lower than that in the actual environment. It is necessary to evaluate EBCs using a burner rig to investigate the degradation behavior of EBCs in a gas turbine environment. However, there are only a limited number of cases in which EBCs have beenV evaluated using a burner rig [2], and previous studies have often focused only on the recession behavior of the topcoat. Therefore, we performed burner rig tests to evaluate the degradation behavior until delamination.

Yb_2SiO_5/mullite/Si-coated SiC/SiC CMCs were used as the burner rig test samples; Yb_2SiO_5 (100 μm), mullite (50 μm), and Si (50 μm) layers were deposited onto SiC/SiC CMC substrates (approximately 3 mm thickness) using atmospheric plasma spray (APS). The specimens were evaluated in a burner rig test facility, as illustrated in Figure 1. The EBC surface was heated using an oxygen/CH4 burner, whereas the backside was cooled using compressed air. The estimated gas velocity of the burner flame was 20 m/s, and the estimated H_2O content in the flame was 65 vol.%. The temperatures of the EBC surface and backside of the CMC were measured using radiation thermometers. The test temperature was set to 1440 °C for the EBC surface and 790 °C for the backside. Cyclic heating tests were performed with heating and cooling times of 3 min.

The test was interrupted after 1350 cycles because partial EBC delamination was observed (Figure 2(a)). From the optical microscopy image (Figure 2(b)) and scanning electron microscopy image (Figure 2(c)) of the cross-section of the delaminated area, it was confirmed that thermally grown oxide was formed along the cracks owing to the oxidation of the Si bond coat. In addition, the mullite layer appeared porous, owing to steam oxidation. Because no recession of mullite was reported in the furnace steam oxidation tests [1], it is considered that this degradation phenomenon is unique to the burner rig test. Under conditions in which EBCs are exposed to high-velocity water vapor, water vapor may penetrate the EBCs through cracks generated during cyclic tests and cause recessions in the intermediate layer.

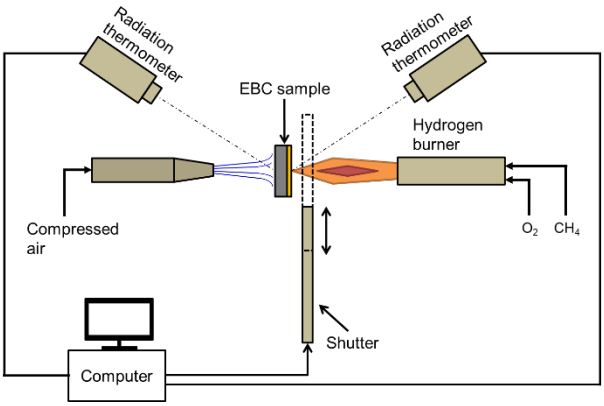

Figure 1 – Schematic representation of burner rig test

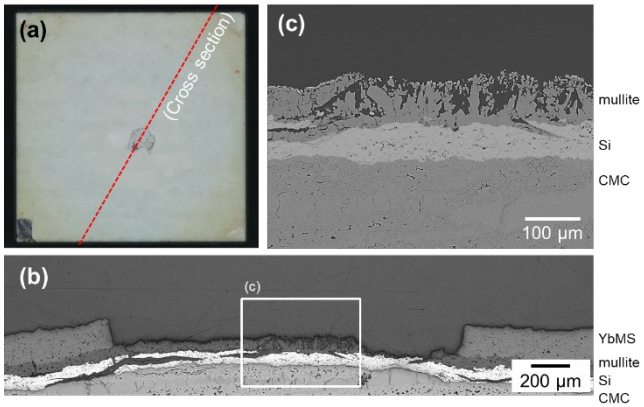

Figure 2 – EBC sample after burner rig test. (a) appearance; (b)(c) cross-section images.

[1] B. T. Richards, et. al., J. Am. Ceram. Soc., 98, 4066-4075 (2015).
[2] E. Bakan, et. al., J. Euro. Ceram. Soc., 40, 6236-6240 (2020).